LAND USE LAND COVER CHANGE DETECTION OF URBAN AREA USING RS AND GIS - A CASE STUDY OF VISAKHAPATNAM DISTRICT, INDIA

Abstract

In rapidly growing urban regions, like Visakhapatnam in India, the dynamic changes in land use and land cover (LULC) present significant challenges and opportunities for sustainable development. The urban landscape of Visakhapatnam has significantly changed during twenty-three years (2000–2023) due to economic development and population expansion. To find out LULC changes in lower atmosphere, the researchers studied the remote sensing data provided by the US Geological Survey (USGS) and other sources. Geographical information systems (GIS) and multi-temporal satellite data are used to classify and track data for temporal land use changes. In the present study the LULC is classified into six classes, namely built up areas, water bodies, industrial land, bare land, forest vegetation and agricultural lands. More notably, between the 23 years, built up area and industrial land has seen remarkable growth rates and rising from 8% and 18% to 1% and 10% accordingly. These are very insightful discoveries that have implications for decision of planning for sustainable development and urban planning. When applied to such data resources, stakeholders would be better placed to address the many issues associated with urbanization and the achievement of long term environmental and socio-economic goals.

Keywords: Land use Land cover, ArcGIS, supervised classification, urbanization, built-up area and industrial area.

Authors

Barhmaiah Borigarla
Assistant Professor
Department of Civil Engineering
Vignan's Institute of Information Technology (A), Visakhapatnam.
brahmamg44@gmail.com

Rajesh Adigarla
Student
Department of Civil Engineering,Vignan's Institute of Information Technology (A)
Visakhapatnam, India.
rajeshh272001@gmail.com,

Jyotheesh Alla
Student
Department of Civil Engineering,Vignan's Institute of Information Technology (A)
Visakhapatnam, India.
jyotishalla12@gmail.com

I. INTRODUCTION

LULC variations are significant environmental transformations occurring globally. It refers to changes in the physical attributes of the earth surface caused by human activity. These changes involve a range of phenomena, including urbanization, industrialization, deforestation, and infrastructure development [2, 12, and 15]. India is quickly urbanizing, with a growing population and increased migration from rural to urban areas. The process of urbanization results in the transformation of natural habitats and agricultural land into built-up regions, which affects biodiversity, water resources, and ecosystems.

II. RELATED WORK

Planning appropriate urban development in rapidly expanding cities like Visakhapatnam, India, requires LULC detection. From 1941 to 2009, [6] noted LULC fluctuations in Visakhapatnam. Topographical maps collected from the Survey of India and Cartosat-1 in 2009 and IRS-1D LISS-III in 2003. The study identified essential changes, such as replacing agricultural villages with a steel mill in 1991 and altering fishing communities following the development of Gangavaram port in 2005. These changes highlight the study area's dynamic land use for urban development and environmental management. Further, geospatial technology was used to study LULC variations in the Thadipudi Reservoir from 2005–06 to 2015–16. The study emphasized how human activities resulting in changes in land usage. They described considerable changes in the forest area, with a loss of 177 square kilometers attributed to various anthropogenic activities. The study used Landsat TM and Landsat OLI data and achieved an accuracy of 92.3% in 1988 and 86.7% in 2020 [11].

Accurate identification of changes in LULC plays a crucial role in its future prediction. Variations in LULC patterns using various techniques, including satellite data collected by RS&GIS techniques, followed by image processing and classification. To create LULC maps, they used the maximum likelihood classification (MLC) technique in conjunction with ArcGIS and ERDAS [9]. LULC from 2000 to 2019 was based on topo-sheets and satellite imagery interpretation, indicating differences in populated areas. Population growth and economic development primarily drove the significant increase in urbanization between 2000 and 2019. Found that Changes in LULC are critical for identifying sustainable land management techniques and conservation activities[8]. MLC technique for image classification and assessment of classification accuracy. Their research revealed considerable changes in the LULC classes within the Hesaraghatta watershed [4]. The results showed that 16.46% of the study area was uncultivated, 59.48% was cultivated, and 4.66% was built-up land. 0.94% of the land was changed overall by wastelands, but the amount of developed and uncultivated land rose by 13% and 85%, respectively.In 32 years, the National Marine Fisheries lost 39% of its land area, with the third era experiencing the most trees cut down [3]. Parsed and spotted trends in LULC change on a regional level with RS and GIS. According to the findings, there was a dramatic decline in the NMF, but the area of bare earth, urban spaces, cardon agriculture and orchards all increased. During the 32 years under study, 39% of the NMF's land area was lost, with that loss accelerating sharply in the third era. It is expected that, within the next 15 years, half of the region's forests could be removed, bringing environmental problems to the study area [7].

To refine the spectral signatures, LULC changes were examined using open-source data and clustering. Landsat data and the TWDTW classifier enabled them to successfully identify types of LULC in 21 years of satellite imaging, allowing them to think about long-term changes [5]. Changes in LULC were studied using normalized different vegetative index (NDVI) and semi-supervised image classification (SSIC). Each technique produced similar accuracy results for Landsat-5 (TM) photos taken in 1993, 1999 and 2001. When averaged, SSIC outperformed NDVI in accuracy by 82% as opposed to 69%. From these studies, MLC and unsupervised classification are found to be most suitable for reliable LULC identification and stress the need to monitor LULC for sustainable land care and the environment [13]. Morphological land change analysis and change detection tools were used in this research to find LULC transformations across the last thirty years and predict the future LULC of Visakhapatnam.

III. METHODOLOGY

In this study, LULC changes analyzed using demographic dataand satellite images. MLC and a range of change detection methods used to identify and classify LULC features. Satellite images examined separately before carrying out the change detection. Once all the maps were classified, we analyzed them by interpreting each map layer on the screen. In this study also predicted the population for 2030 and calculated the related land use changes. The methodology for LULC assessment is explained in Figure 1.

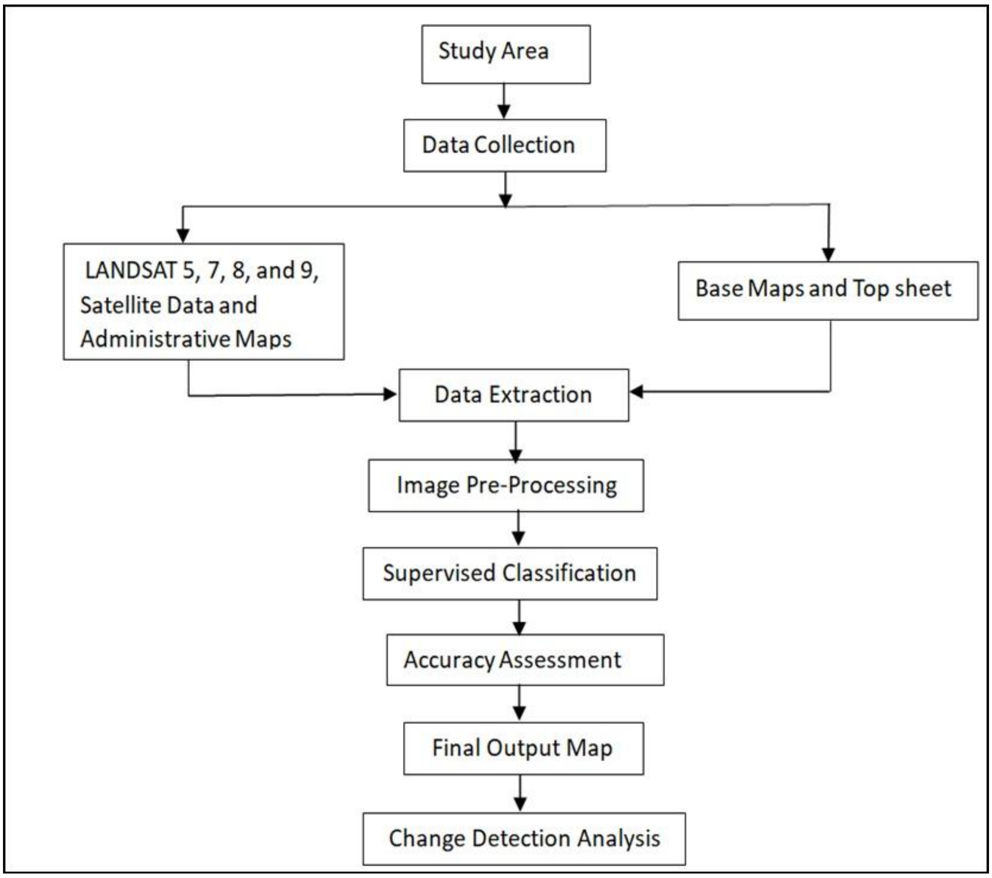

Figure 1: Methodology for assessment of LULC

1. Study Area

The study examines changes in LULC in Visakhapatnam District, Andhra Pradesh, India. The district is located in the northeastern section of the state, spanning between 17° 35' 73" N and 82° 54' 43" N latitude and 17° 88' 89" N and 83° 45' 25" E longitude, comprising roughly 4317 square kilometers (Fig 2). The area has a diversified landscape, including agricultural fields, forests, urban areas, bodies of water, and barren territory. The district is well-known for its agricultural output and has a significant economic impact on the state. Despite this, continuous development and urbanization pressures have resulted in substantial variations in LULC.

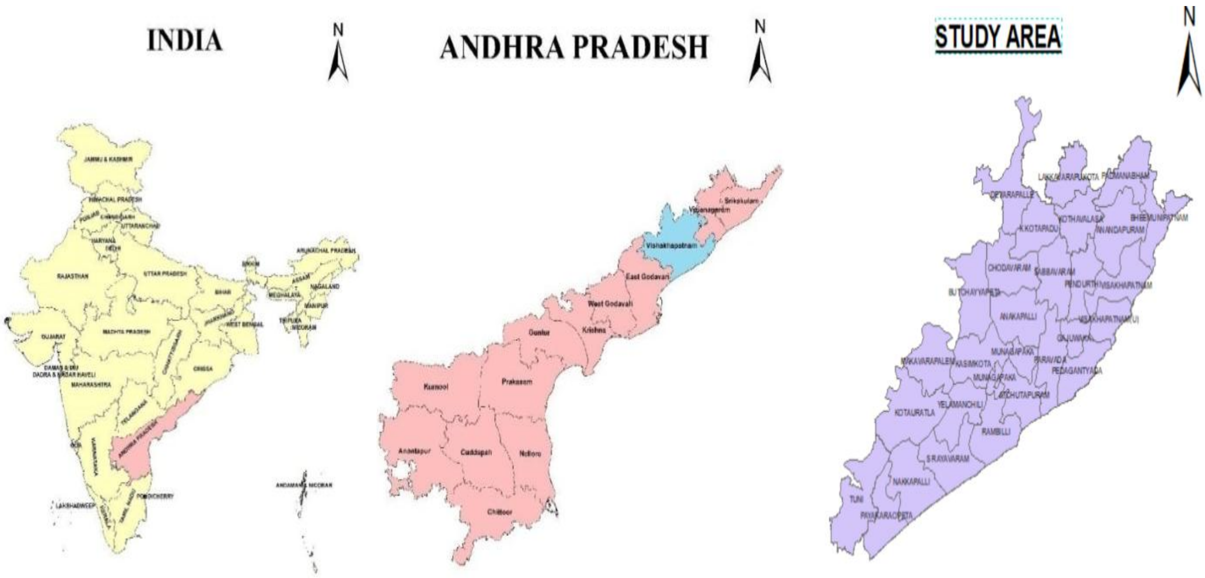

Figure 2: Study area of Visakhapatnam District, Andhra Pradesh, India.
(Source: www.diva-gis.org)

2. Data Collection

The longest and most comprehensive temporal report of the earth's surface is seen in Landsat data. It is the only data source with high spatial resolution (30 m). We downloaded the accessible Landsat data (< 30% cloud cover) from 1995 from the US Geological Survey to create our lengthy time series and get extensive temporal continuity data. The USGS offers a web-based interface called USGS Earth Explorer, which enables users to search, find, and download remotely sensed data such as satellite imaging and aerial photography. Numerous datasets are accessible through it, such as those from Sentinel satellites, Landsat, and other Earth observation programs. Users can do targeted data searches by entering parameters like location, date range, sensor type, and cloud cover %. Interactive maps and tools for filtering search results and previewing images before downloading are available on the interface. Registered users can also retrieve their download history and save their search parameters for later use.USGS Earth Explorer extensively for various purposes, such as natural resource management, land use studies, environmental monitoring, and disaster response. The Landsat 5, 7,8 & 9 for different time series. DIVA-GIS is a computer program used for mapping and analysis of geographic data. With this, we can create and download small area maps like state boundaries, rivers, and a satellite image, and the locations of the store's distinct time series are Landsat 5, 7, 8, and 9. A free computer program for mapping and analyzing geographic data is called DIVA-GIS. This allows us to make and download small area maps, such as those showing rivers, state borders, the location of the place, and satellite images.

3. Data Extraction

In this study, we extracted the study region from administrative maps and satellite imagery based on the selected area. We used ArcMap 10.8 and ArcGIS Pro software to extract data from satellite images. This extracted data formed the basis for analyzing and generating the final LULC maps. ArcMap 10.8, developed by Esri, is a geospatial tool for viewing, editing, managing, and analyzing geographic data across web, mobile, and desktop platforms. It allows users to analyze spatial data and create custom maps with layered representations of various geographic features. In our analysis, we used several ArcMap tools, including raster calculators, clipping functions, extraction tools from the Spatial Analyst toolbox, and layout creation tools. We also used ArcGIS Pro, which provides advanced tools for visualizing, editing, and analyzing local and online geographic data. ArcGIS Pro supports complex workflows by allowing users to manage charts, tables, layouts, and maps within a single project interface. In this study, ArcGIS Pro was used to verify the accuracy of the classified satellite images and enhance the visual representation of our LULC analysis.

4. Image Pre-processing and Classification

To improve the output accuracy of the satellite photos, pre-processing of the images is required. Numerous corrections, including geometric, cloud, and shadow detection, are included in the pre-processing. Geometric corrections use GPS to achieve precise findings and surface reflectance values between the time series and locations. It entails correcting distortions and aligning the geodetic reference system. Digital elevation models (DEM) are primarily utilized for precise georeferencing. As seen in Figure 3, the research area's LULC categorization was mainly based on multi-temporal satellite photos from 2000, 2005, 2010, 2015, 2020, and 2023, as shown in Figure 3. Using the features of image interpretation, the photos are geo-coded FCC. The photos were categorized using supervised classification into six groups: industrial area, built-up area, barren land, agricultural land, forest vegetation, and aquatic body. A different color represents every class in the LULC map.

IV. RESULT AND DISCUSSION

The supervised classification of various years, i.e.,2000,2005,2010,2015,2020 and 2023, in different LULC categories like water bodies, barren land, built-up, agriculture land, forest, and industrial area. The prepared LULC maps using ArcGIS are shown in Figure 3. The results show the gradual change in the Visakhapatnam mandals over 23 years. Visakhapatnam is a place for industry and tourism due to the coastal area.

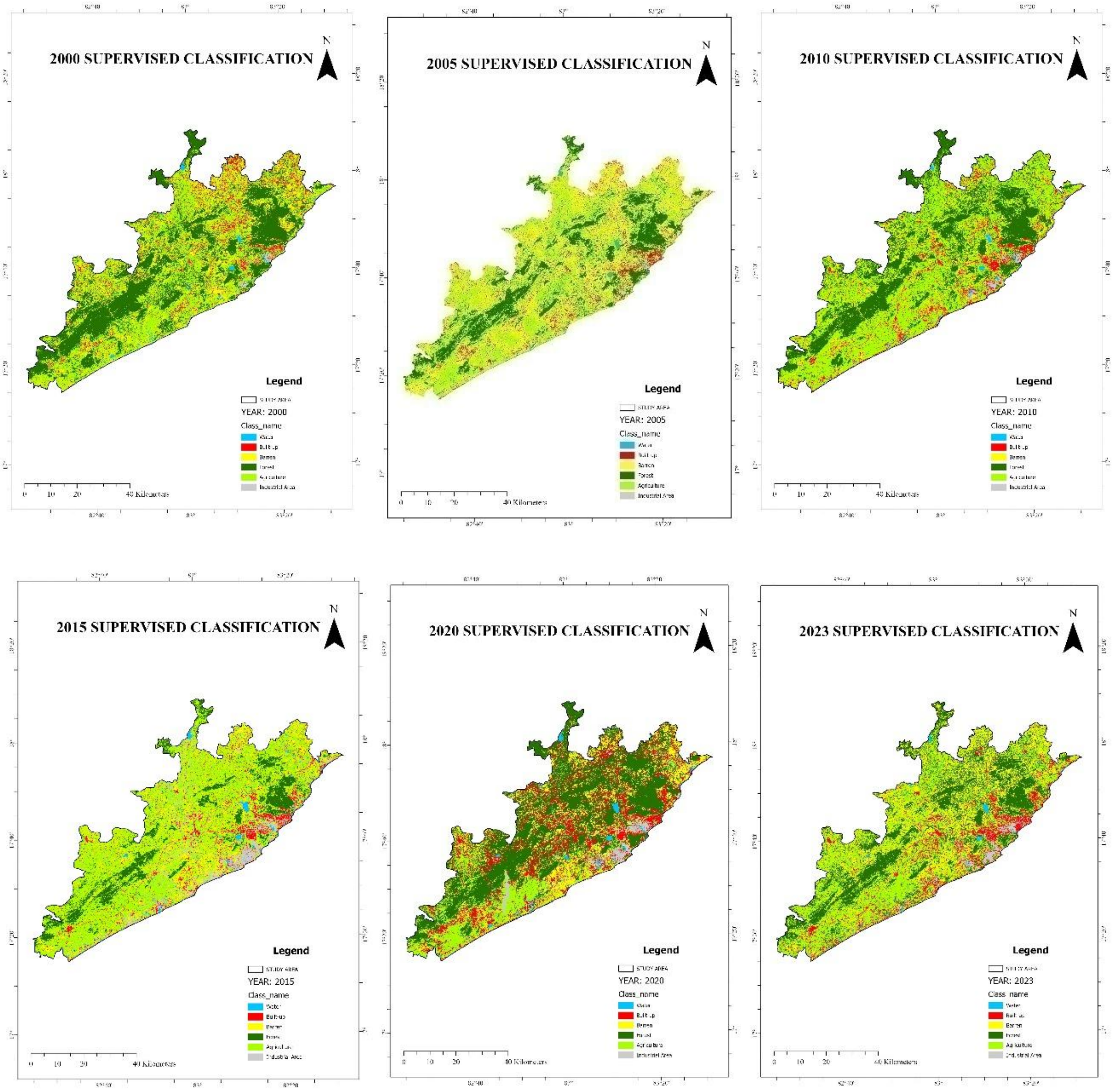

Figure 3: Supervised classification of LULC maps from 2000 – 2023 (Developed by using ArcGIS)

In 2000, Visakhapatnam's land use was characterized by a diverse landscape. Water bodies covered 72.7 km² (1.68%), while the built-up area occupied 344.84 km² (7.98%). The major land cover classes included agricultural lands (1615.54 km², 37.42%), industrial areas (55.92 km², 1.29%), forests (1515.55 km², 35.10%), and barren lands (712.57 km², 16.50%). The city exhibited a balance between urban, agricultural, and natural land covers, as shown in Figure 3 and Figure 4. Land use patterns have undergone a substantial change by 2005. Barren land increased from 712 km² to 1518 km² (16% to 35%), most likely due to conversion or land degradation. Water bodies decreased from 2% to 1%, indicating potential encroachment or degradation. While agricultural land fell from 37% to 33%, the amount of forest cover declined from 35% to 21%. Built-up area increased due to urbanization, resulting from population growth and urban expansion, as shown in Figure 5. Urban growth pattern of coastal cities in India. The exponential growth pattern was due to increased migration; a 10% increase was reported in the built-up area[13]. Continuous encroachment and pollution of water bodies, mainly due to urban pressure and land reclamation for real estate and infrastructure. Their study's decline from 2% to 1% of water bodies validates this trend and underlines environmental degradation[14].

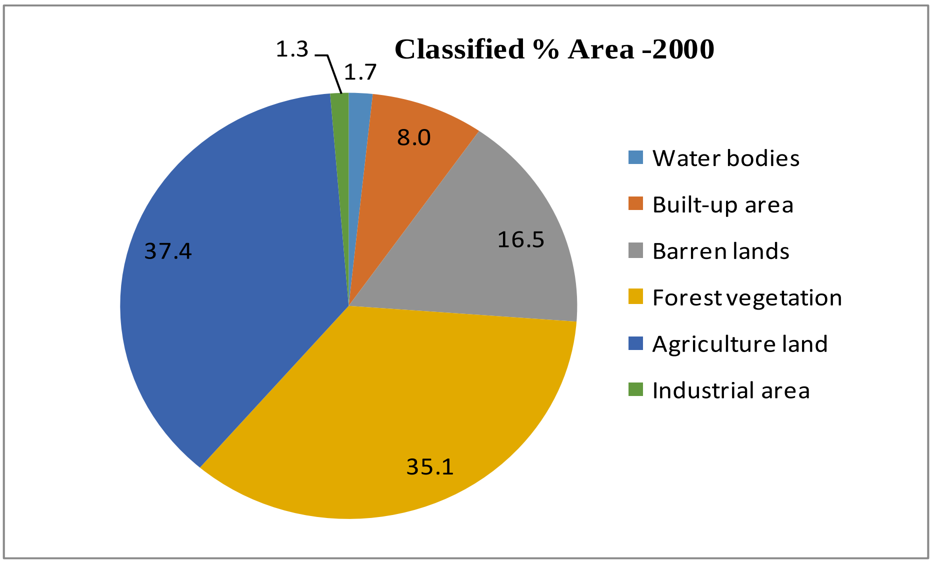

Figure 4: LULC in 2000

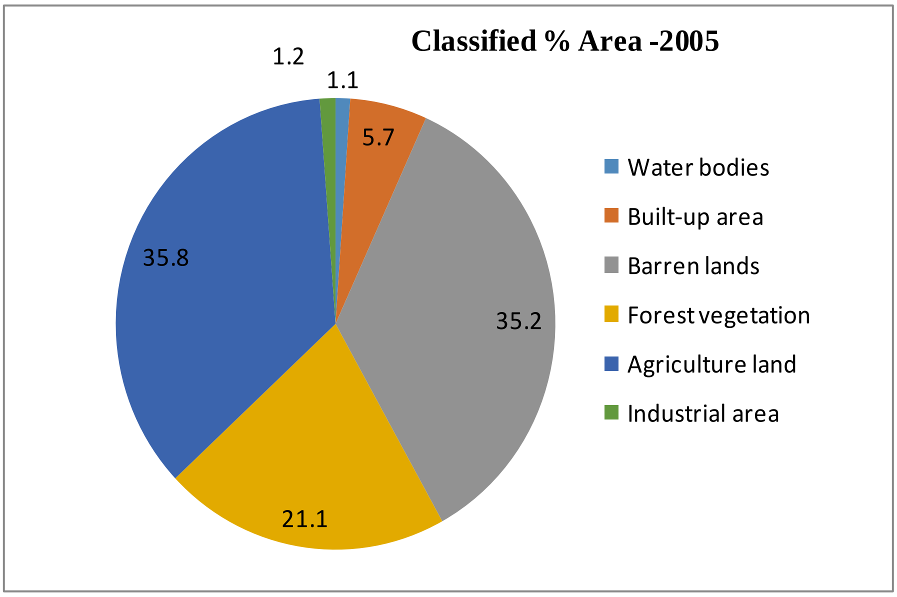

Figure 5: LULC in 2005

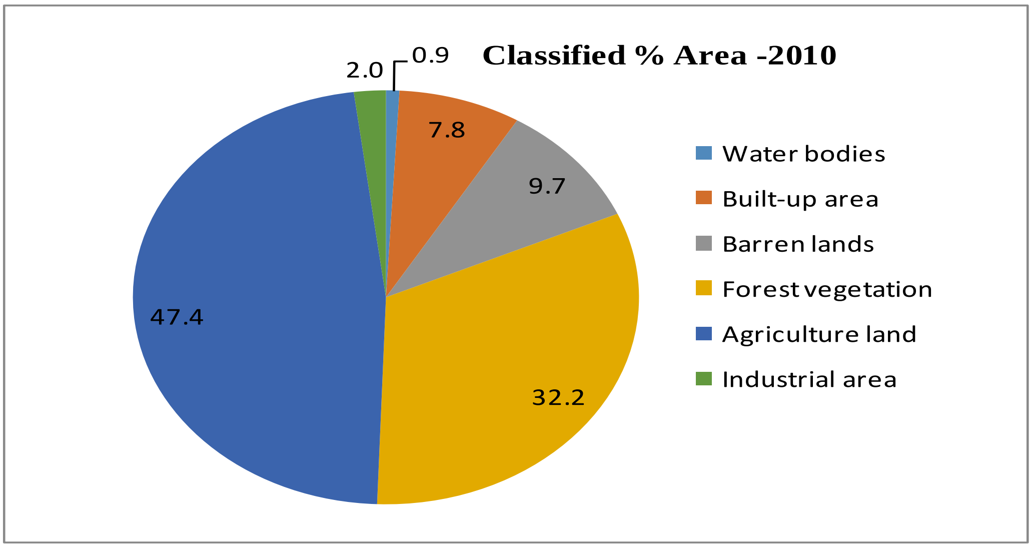

Figure 6: LULC in 2010

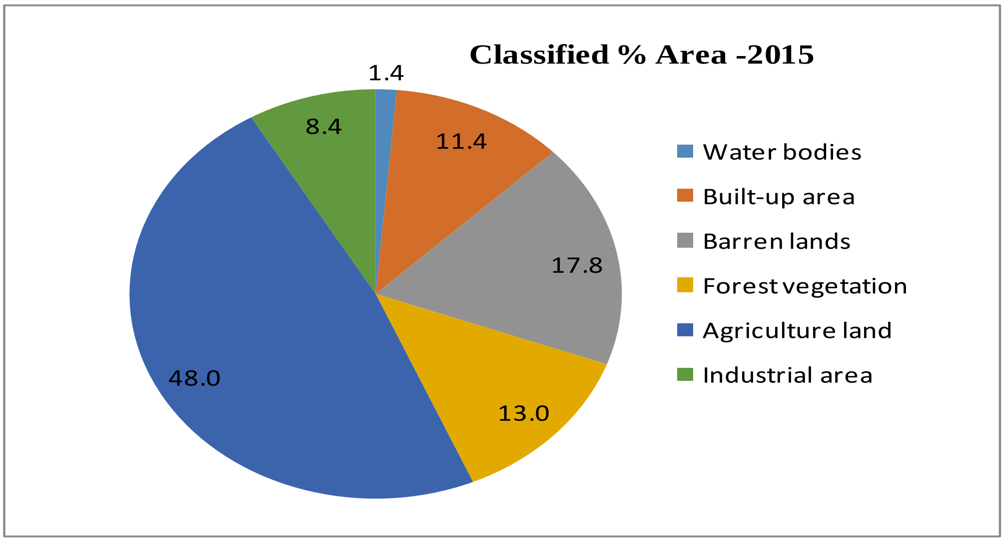

Figure 7: LULC in 2015

Due to alterations in land use regulations or agricultural methods, the percentage of land used for agriculture rose to 47% in 2010. More than 80% of the built-up area, indicating ongoing urbanization tendencies. The growth in industry is due to the increase in the number of pharma companies in the study area, as the author [6] expected. Increasing vegetation cover caused barren land to drop to 10%, while forest cover climbed to 32%, potentially due to afforestation or natural regeneration. Following Cyclone Hud Hud's devastating effects on property and vegetation in 2015, the percentage of forest cover fell from 32% to 12%. Some wooded areas turned into fields for farming or other purposes. Separating states stimulated economic activity since industrial growth grew from 2% to 8%[14].

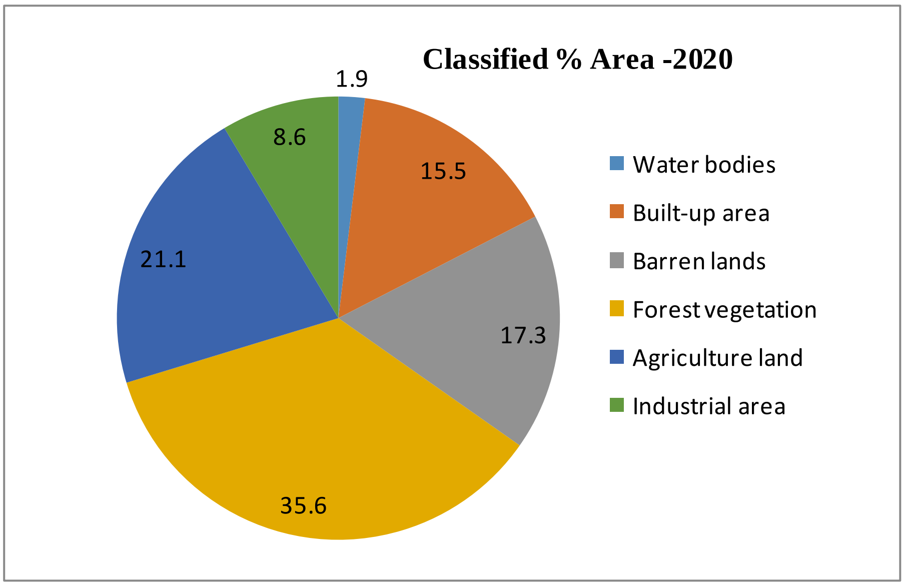

Figure 8: LULC in 2020

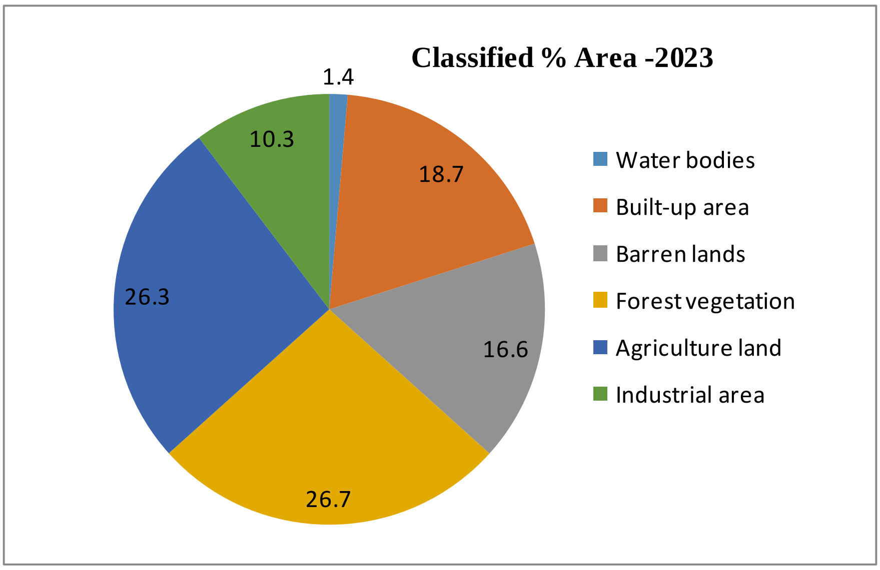

Figure 9: LULC in 2023

As a result of post-cyclone restoration efforts, the amount of forest vegetation increased rapidly in 2020, from 13% to 35%. Land used for agriculture declined due to reforestation initiatives or other changes. The continuous urbanization tendencies caused the built-up area to increase from 11% to 18%. Water bodies dropped from 2% to 1% by 2023, presumably due to invasion or degradation. The percentage of land used for agriculture rose from 21% to 26%, suggesting possible modifications to land use regulations or agricultural methods. Due to the fast urbanization, built-up areas increased from 15% to 18%.

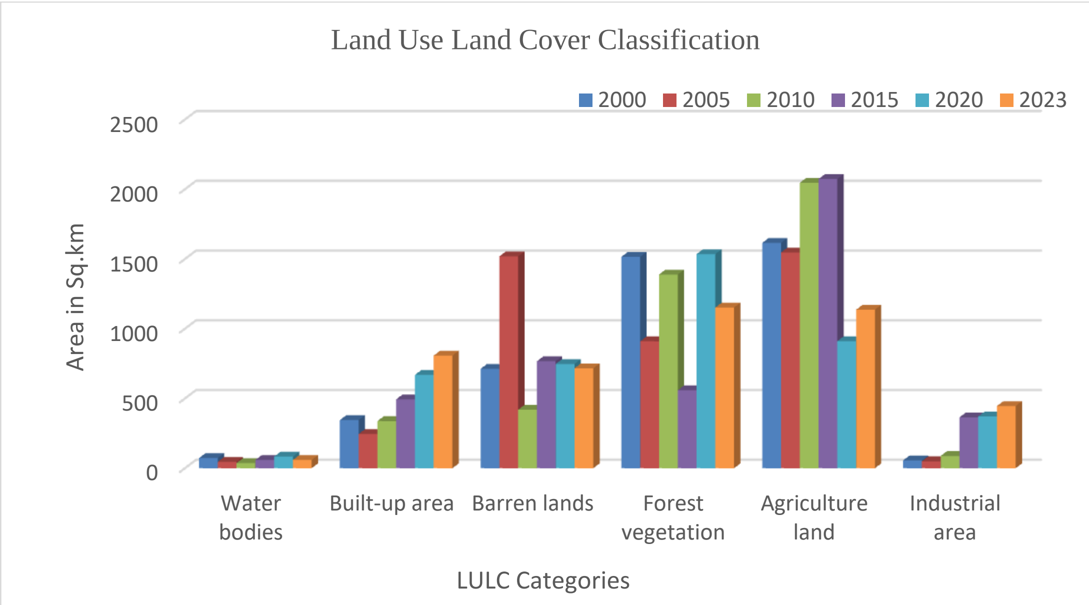

Figure 10: LULC Classification for 2000-2023

In Andhra Pradesh, especially in Visakhapatnam, there was a notable shift in emphasis following the division of Telangana and Andhra Pradesh toward revenue collection and general development. The government started several infrastructure initiatives to improve connectivity, boost economic expansion, and accommodate the growing population. A vital infrastructure undertaking was building the Anakapalli flyover and creating a route connecting Anakapalli with Anadaapuram. These programs were designed to reduce traffic jams and make it easier for people and goods—huge vehicles—to move throughout the city, easing the strain on the city's road systems. Between 2017 and 2023, the built-up area grew dramatically due to population growth and the need for residential, commercial, and industrial space. The spike in residential occupancy largely facilitated the expansion of the built-up area. More people moved to Visakhapatnam for work and higher living conditions, which increased demand for housing and associated infrastructure and accelerated urbanization and land cover change.

Additionally, the tourism industry had a notable uptick in growth during the 21st century. An increasing number of tourists visit Visakhapatnam annually due to its strategic location, cultural legacy, and natural beauty. The built-up residential and commercial areas increase in tandem with population expansion, as seen in Figure 11. However, the expansion rate might not be linear and influenced by land use regulations, infrastructural development, and urban planning techniques. There may be a more precise pattern in agricultural land. Although there are fluctuations in the data, there isn't a consistent growth or decrease in line with population growth. Numerous things could be to blame for this, such as modifications to farming methods, changes in land use regulations, and urbanization of agricultural areas. The population increases cause the industrial area to grow more quickly. This is probably because more industries created and grown to supply the goods and jobs the growing population needs. Over the last few years, the significant rise in industrial areas suggests that the region is rapidly industrializing.

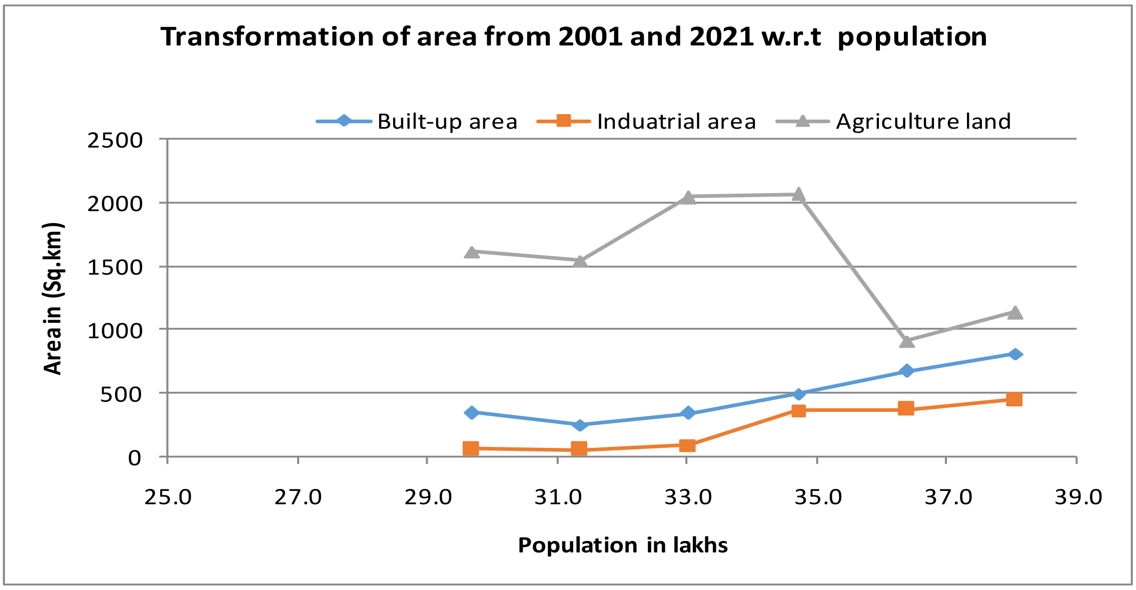

Figure 11: Transformation of LULC with Population growth

V. CONCLUSION

1. Visakhapatnam has undergone significant LULC transformation driven by rapid urbanization, industrialization, and infrastructure development. Notable growth in built-up and industrial areas, especially near HPCL and Gangavaram Port, has resulted in habitat loss and agricultural land decline, aligning with earlier projections for 2021.
2. Reducing water bodies is linked to industrial expansion, increased runoff into residential and industrial zones, and climatic shifts. It threatens biodiversity and highlights the urgent need for sustainable urban planning and land management.
3. Built-up areas increase by 11.92%, industrial areas by 7.54% per lakh population growth, and agricultural land decreases by 0.49%. This reflects urban sprawl and industrial expansion driven by population demands.
4. Population growth strongly influences land use dynamics in Visakhapatnam. Continuous monitoring and sustainable planning are essential to balance development with environmental conservation.

ACKNOWLEDGEMENT

"The facts and views in the manuscript are ours and we are totally responsible for authenticity, validity and originality etc. I / We undertake and agree that the manuscripts submitted to your journal have not been published elsewhere and have not been simultaneously submitted to other journals. I / We also declare that manuscripts are our original work and we have not copied from anywhere else. There is no plagiarism in our manuscripts. Our manuscripts whether accepted or rejected will be property of the publisher of the journal and all the copyrights will be with the publisher of the journal".

REFERENCES

[1] Ahmad, Naseer. Spatio-Temporal Change Detection Analysis of Land Use Land Cover of Bathinda District, Punjab, India. *Biosci. Biotechnol. Res. Asia*, **20**(2), 571 (2023).
[2] Alawamy, Jamal S., Balasundram, S. K., Hanif, A. H. M., & Sung, C. T. B. Detecting and Analyzing Land Use and Land Cover Changes in Al-Jabal Al-Akhdar, Libya. *Sustainability*, **12**, 4490 (2020).
[3] Bharath, A., Manjunatha, M., Tangadagi, R. B., Preethi, S., & Dangeti, M. Assessment of LULC Changes for Hesaraghatta Watershed. *Nat. Environ. Pollut. Technol.*, **20**, 1749 (2021).
[4] Chughtai, Ali H., Abbasi, H., & Karas, I. R. A Review On Change Detection Method and Accuracy Assessment for LULC. *Remote Sens. Appl.: Soc. Environ.*, **100482** (2021).
[5] Dongarea, P., Sharma, K. V., Kumara, V., & Mathew, A. Water Distribution System Modelling. *J. Hydroinformatics*, **00**, 1 (2024).
[6] Latha, P. S., & Rao, K. N. Assessment of Land Use and Land Cover Changes (1988-2020). *Int. J. Res. Rev.*, **7**, (2020).
[7] Ramesh, K., Asha, R., & Jamuna, E. Assessment of Land Use/Land Cover Change Detection of Mettupalayam Taluk. *GSC Biol. Pharm. Sci.*, **22**(1), 241 (2023).
[8] Rao, C. N. R. Chemical Applications of IR Spectroscopy. Academic Press, London, 250 (1963).
[9] Reddy, C., Venkata, M., & Choudhary, M. Estimation of Damage to Agriculture Biomass due to HUDHUD Cyclone. *Geocarto Int.*, **32**, 1 (2016).
[10] Swarna Latha, P., & Rao, K. N. Assessment of LULC Changes (1988-2020) through NDVI Analysis. *Int. J. Res. Rev.*, **7**, (2020).
[11] Viana, C. M., Girão, I., & Rocha, J. Long-Term Satellite Image Time-Series for LULC Detection. *Centre for Geographical Studies*, **12**, (2019).
[12] Vanum, G., & Hadgu, K. M. LULC Changes and Implications on Sustainable Land Management. *Int. J. Geol. Earth Environ. Sci.*, **2277-2081**, 136 (2012).
[13] Rai, C. K., Goyal, S. K., Raj, K., & Kumar, V. Impact of Urbanization on Peri-Urban Agriculture. Springer, Singapore (2025).
[14] Kota, S., & Raju, A. J. A Study on Decadal Changes of Kambalakonda Lake. *IJCRT*, **2320-2882** (2021).
[15] Singh, D. K., Reddy, D. M. A., & B, N. K. LULC Information of Medchal Mandal. *IJEAT*, **9**(2), 4682 (2019).